

NITROGEN SPECIATION IN A ^{15}N -ENRICHED INTERPLANETARY DUST PARTICLE. L. P. Keller¹, S. Messenger², M. Miller¹, and K. L. Thomas³, ¹MVA, Inc. 5500 Oakbrook Parkway, Suite 200, Norcross, GA 30093 (E-mail: lkeller@mva-inc.com). ²McDonnell Center for Space Sciences, Washington University, St. Louis, MO 63130, ³Code C23, Lockheed, NASA/JSC, Houston, TX 77058.

Nitrogen concentrations have been observed in carbonaceous material from several interplanetary dust particles (IDPs) using electron microscopy techniques [1]. Coordinated ion probe measurements on the same particles studied by TEM shows that large bulk excesses in ^{15}N are associated with the N-bearing IDPs [2]. Although the carrier phase(s) of the ^{15}N enrichments in IDPs are not known, organic matter and nitrides have been suggested as likely candidates. In this study, we used a combination of electron energy-loss spectroscopy (EELS) along with fourier-transform infrared (FTIR) microspectroscopy to determine the speciation of N in an isotopically anomalous IDP.

The IDP we studied is L2011R11, and details of its mineralogy, petrography and isotopic systematics are given in [1-3]. L2011R11 is a track-rich chondritic-porous IDP with 3X CI bulk carbon and has a mineralogy dominated by low-Ca pyroxene, FeNi sulfides, GEMS (glass with embedded metal and sulfides), and carbonaceous material. While the carbon isotopes in L2011R11 are normal, a ^{15}N excess of 250‰ and a moderate D excess of 200‰ is observed [2].

Following the SEM-EDX measurement of bulk composition, L2011R11 was embedded in sulfur, and thin sections prepared using ultramicrotomy. The thin sections were placed on SiO thin films for TEM analysis, while the unsectioned remainder of the IDP was extracted and used for the ion probe measurements. The location and bonding state of the N was investigated using EELS. Differences in the N k-edge fine structure (e.g. spectrum shape, relative intensities of features, peak positions) provide information on the local solid state bonding environment of N within the analytical volume. Background-subtracted spectra of the N k-edge in L2011R11 and several N standards are collected in Figure 1. A comparison of the L2011R11 spectra to the standards, shows that the major N-bearing component in L2011R11 is not nitride, nitrate, or cyano-nitrogen. Furthermore, from the high-resolution TEM images and electron diffraction data from the carbonaceous material in L2011R11, no crystalline inclusions >5-10 nm have been observed. Based on the electron microscopy data, we hypothesized that the N was carried in an organic phase, and we have subsequently collected FTIR spectra from L2011R11 thin sections.

The FTIR transmission spectra were collected using an IRμS (Spectra-Tech) infrared microscope equipped with a thermal emission source. Spectra were obtained from ultramicrotome thin sections (~70 nm thick) supported on a SiO thin film, over the range 2.5 to 15 μm, by adding

successive interferograms (typically 4000 scans). Background spectra were obtained from the SiO thin film adjacent to the thin sections. The final spectrum (Figure 2) was background-subtracted and smoothed.

The two major bands in the FTIR spectra occur at ~3 μm and at 6 μm and are consistent in both intensity and position with the characteristic N-H stretching and bending vibrations, respectively, in secondary amines. C-N absorptions in secondary aliphatic amines are observed at 7.1 μm and between 8.2-9.8 μm, but are typically weak. The bands in the L2011R11 spectra in these regions can be attributed to this C-N bond. The band at 3.4 μm is typical of aliphatic C-H stretches while the weak bands between 4.8 and 5.2 μm is suggestive of aromatic overtones. These results indicate that the majority of the N is associated with an organic phase.

The enrichments in ^{15}N and D observed in certain meteorites and IDPs are believed to result from low-temperature ion-molecule reactions in presolar molecular clouds [e.g. 4]. Although IDPs which exhibit ^{15}N enrichments also tend to be enriched in D, D-rich IDPs do not necessarily show excess ^{15}N [2,4]. It has been suggested that the carrier phase(s) for the D and ^{15}N are not the same [2]; while D anomalies have been strongly linked to carbonaceous material [e.g. 5], the potential carriers for ^{15}N suggested thus far in the literature include the PAHs in some IDPs which show distinctive odd-mass spectra [6]. The heavy N in certain CR carbonaceous chondrites has also been linked to organic material [7].

Large ^{15}N excesses have been measured in individual interplanetary dust particles. Transmission electron microscopy combined with spectroscopic measurements of the same IDPs show N concentrations within the carbonaceous material and that much of the N is present in an organic form. The isotopic signature suggests formation of the N-bearing carbonaceous material in a cold, presolar, molecular cloud. An important implication is that the solid mineral grains embedded in the ^{15}N -rich carbonaceous matter may also be of presolar origin.

References. [1] Keller, L. P. *et al.*, 1996, *MPS* 30, 526. [2] Messenger, S. *et al.*, 1996, *MPS* 31, 88, [3] Keller, L. P. *et al.*, 1996, *LPSC*, 27, 659, [4] Stadermann, F. J. *et al.*, 1989, *Meteoritics* 24, 327, [5] McKeegan, K. D. *et al.* 1987, *LPSC* 18, 627, [6] Clemett, S. *et al.*, 1993, *Science*, 262, 721. [7] Ash, R. D. *et al.*, 1993, *Meteoritics*, 28, 318.

Acknowledgements: This work was supported in part by NASA Contracts NASW-5046 and NASW-96028.

Figure 1. Electron energy-loss spectra for the N k-edge in L2011R11 and various N standards.

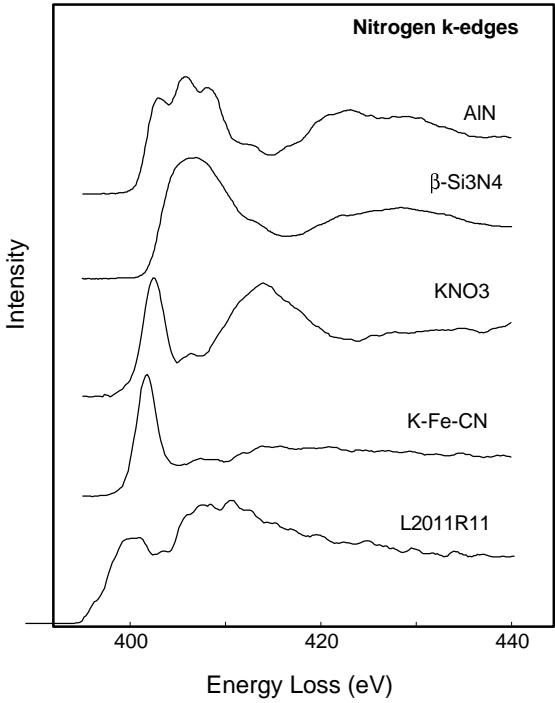


Figure 2. FTIR transmsion spectrum from a thin section of L2011R11. Major N-H bands occur at ~3 and 6 μ m

